Strategic Astrophysics Technology

Advanced Antenna-Coupled Superconducting Detector Arrays for CMB Polarimetry

Completed Technology Project (2013 - 2015)

Project Introduction

We propose to develop advanced, high-sensitivity millimeter-wave detector arrays for measuring the polarization of the cosmic microwave background (CMB). The arrays are based on planar antennas that provide beam collimation, polarization analysis, and spectral band definition in a compact lithographed format that eliminates discrete fore-optics such as lenses and feedhorns. The antennas are coupled to transition-edge superconducting bolometers, read out with multiplexed SQUID current amplifiers. This development is directed to advance the technology readiness of the Inflation Probe mission in NASA's Physics of the Cosmos program. The superconducting sensors and readouts developed in this program share common technologies with NASA X-ray and FIR detector applications. The Inflation Probe is a fourth-generation CMB satellite that will measure the polarization of the CMB to astrophysical limits, characterizing the inflationary polarization signal, mapping large-scale structure based on polarization induced by gravitational lensing, and mapping Galactic magnetic fields through measurements of polarized dust emission. The inflationary polarization signal is produced by a background of gravitational waves from the epoch of inflation, an exponential expansion of space-time in the early universe, with an amplitude that depends on the physical mechanism producing inflation. The inflationary polarization signal may be distinguished by its unique 'B-mode' vector properties from polarization from the density variations that predominantly source CMB temperature anisotropy. We propose to advance specific aspects of antenna-coupled superconducting detectors that will be needed for space-borne technology readiness. We will: (1) extend our antenna designs to frequencies 40 - 220 GHz that will be needed for precise removal of polarized Galactic emission; (2) carry out precise polarized beam matching characterization measurements on a representative crossed-Dragone telescope; (3) develop two dual-band antenna designs that maximize use of available focal plane area; (4) test particle susceptibility to interactions with a thermally engineered detector frame at array level with SQUID readouts; and (5) test the low-frequency noise properties of a microwave resonator-multiplexed radio frequency SQUID readout, a technique which offers potential resource advantages for space. Successful development elements will be independently field-demonstrated in sub-orbital and ground-based experiments.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Strategic Astrophysics Technology

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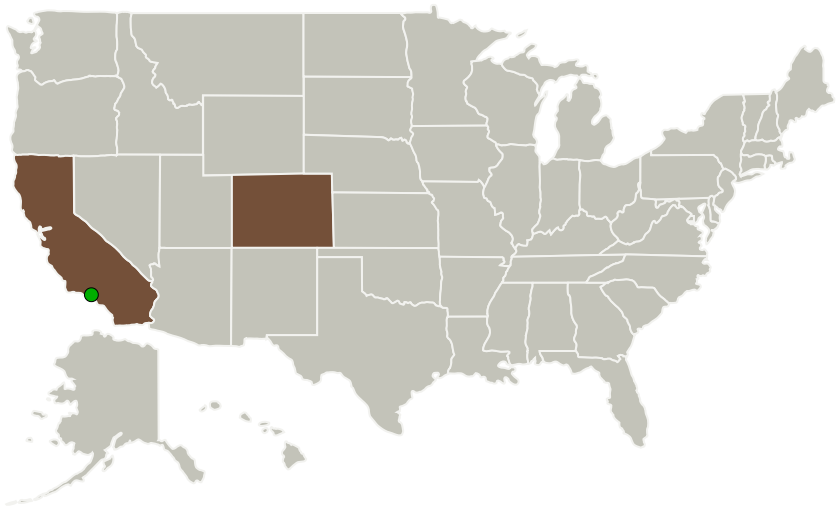
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
National Institute of Standards and Technology(NIST)	Supporting Organization	US Government	Boulder, Colorado

Primary U.S. Work Locations	
California	Colorado

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

James J Bock

Co-Investigators:

Roger Obrient
Jeffrey P Filippini
Martin Lueker
Chao-lin Kuo
Kent D Irwin
Justus A Brevik
Anthony D Turner
Alexis C Weber

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System